

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of : Before the Board of Appeals
Kazuhide Abe : Appeal No.:
Serial No.: 10/766,739 : Group No.: 2814
Filed: January 29, 2004 : Examiner: J. Ingham
: Confirm. No.: 2843

For: WIRING STRUCTURE OF SEMICONDUCTOR DEVICE AND METHOD OF
MANUFACTURING THE SAME

August 13, 2007

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APPEAL BRIEF

U.S. Patent and Trademark Office

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Randolph Building
401 Dulany Street
Alexandria, VA 22314

Date: August 13, 2007

Sir:

In response to the Final Office Action dated January 10, 2007, and further responsive to the Notice Of Appeal filed on June 11, 2007, this corresponding Appeal Brief is respectfully submitted.

I. REAL PARTY IN INTEREST

This application is assigned to Oki Electric Industry Co., Ltd., which is the real party in interest.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences that may be related to, that would directly affect or be directly affected by, or have a bearing on the Board's decision in this pending appeal.

III. STATUS OF THE CLAIMS

Claims 1-11 and 17-27 (canceled).

Claims 12-16 and 28-34 (rejected).

Claims 12-16 and 28-34 have been finally rejected. Accordingly, the rejections of claims 12-16 and 28-34 are being appealed.

IV. STATUS OF AMENDMENTS

Subsequent to the Final Office Action dated January 10, 2007, Appellant submitted an Amendment dated April 10, 2007, canceling claims 3-7 and 9. Pending claims 12-16 and 28-34 were maintained without amendment. As indicated in the Advisory Action dated May 2, 2007, the Amendment dated April 10, 2007, is to be entered for the purposes of Appeal.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The present invention relates to a wiring structure of a semiconductor device, whereby the dielectric strength of the wirings is enhanced and capacitance across the

wirings is reduced by preventing diffusion of wiring material.¹

The wiring structure of a semiconductor device as broadly featured in independent claim 12 includes in combination a first insulating film (101 in Fig. 17) having plural grooves (102) formed therein, which has an interface (101a) in a horizontal direction between adjoining grooves (102) (e.g., page 18, lines 9-11 and as shown in Fig. 17); plural wiring films (105) formed in the grooves (102) of the first insulating film (101) to protrude above the interface (101a) (e.g., page 18, lines 12-14); plural barrier films (103) formed on bottoms of the wiring films (105), and formed on side faces of the wiring films (105) to a height exceeding the interface (101a) (e.g., page 18, lines 14-16); and plural cap films (301) formed at least on upper faces (105a) of the wiring films (105), and which are each separated by the grooves (102) (e.g., page 18, lines 18-20 and page 20, lines 7-9), wherein the first insulating film (101) has plural protrusions (302) protruding from the interface (101a), and the grooves (102) are formed in the protrusions (302) (e.g., page 18, lines 11-12 and page 19, lines 17-19), wherein the upper faces (105a) of the wiring films (105) and the barrier films (103) are substantially coincident with upper ends of the grooves (102) (e.g., page 18, lines 16-18), and wherein the protrusions (302) are formed through etching the first insulating

¹ In the description to follow, citations to various reference numerals, figures and corresponding text in the specification are provided solely to comply with Patent Office rules. It should be understood that these reference numerals, figures, and text are exemplary in nature, and not in any way limiting of the true scope of the claims. It would therefore be improper to import anything into any of the claims simply on the basis of **exemplary** language that is provided here only under the obligation to satisfy Patent Office rules for maintaining an Appeal.

film (101), using the cap films (301) as a mask, and the cap films (301) have substantially the same shape as uppermost faces of the protrusions (302) (e.g., page 18, lines 18-19).

The wiring structure of a semiconductor device as broadly featured in independent claim 28 includes in combination a first insulating film (101 in Fig. 17) having plural protrusions (302) in which grooves (102) are formed, and which has an interface (101a) in a horizontal direction between adjoining protrusions (302) (e.g., page 18, lines 9-12 and as shown in Fig. 17); plural wiring films (105) formed in the grooves (102) on barrier films (103) (e.g., page 18, lines 12-16); plural first cap films (301) formed on upper faces of the protrusions (302) (e.g., page 18, lines 18-19); and second cap films (303) formed on the first cap films (301) and the insulating film (101), wherein the protrusions (302) are formed through etching the first insulating film (101) using the first cap films (301) as a mask, and the first cap films (301) have substantially the same shape as uppermost faces of the protrusions (302) (e.g., page 18, lines 18-19).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The issues on Appeal are:

- (1) The rejection of claims 12-15 and 33 under 35 U.S.C. 103(a) as being unpatentable over the Lim et al. reference (U.S. Patent No. 6,380,084) in view of the Higashi et al. reference (U.S. Patent No. 6,342,444); and
- (2) The rejection of claims 16, 28-32 and 34 as being unpatentable over the

Higashi et al. reference and the Lim et al. reference, in further view of the Yu et al. reference (U.S. Patent No. 6,958,291).

VII. ARGUMENTS

(1) Claims 12-15 and 33 are patentable over the combination of the Lim et al. reference in view of the Higashi et al. reference

Claims 12-15 and 33 have been rejected under 35 U.S.C. 103(a) as being unpatentable over the Lim et al. reference in view of the Higashi et al. reference. This rejection is respectfully traversed for the following reasons.

Claims 12-15 and 33

The wiring structure of a semiconductor device of claim 12 includes in combination among other features a first insulating film "having plural grooves formed therein, which has an interface in a horizontal direction between adjoining grooves"; plural wiring films "formed in the grooves of the first insulating film to protrude above the interface"; plural barrier films; and plural cap films "formed at least on upper faces of the wiring films, and which are each separated by the grooves, wherein the first insulating film has plural protrusions protruding from the interface, and the grooves are formed in the protrusions, wherein the upper faces of the wiring films and the barrier films are substantially coincident with upper ends of the grooves, and wherein the protrusions are formed through etching the first insulating film, using the cap films as a mask, and the

cap films have substantially the same shape as uppermost faces of the protrusions". Appellant respectfully submits that the wiring structure of a semiconductor device of claim 12 would not have been obvious in view of the prior art as relied upon by the Examiner for at least the following reasons.

The Examiner has primarily relied upon Fig. 14 of the Lim et al. reference as meeting the features of claim 12. The Examiner has interpreted second dielectric layer 72 in Fig. 14 of the Lim et al. reference as the first insulating film of claim 12, and as having a groove formed therein (as shown in Fig. 11 also). The Examiner has further interpreted shielding layer 56 and third barrier layer 80 in Fig. 14 of the Lim et al. reference as the plural barrier films of claim 12, and second copper layer 84 as the plural wiring films. The Examiner has also interpreted the hillock of second dielectric layer 72 immediately surrounding second copper layer 84/third barrier layer 80 as the protrusion of claim 12, whereby the upper surface of second dielectric layer 72 peripheral the hillock has been interpreted as the interface of claim 12.

The Examiner has however acknowledged that the Lim et al. reference "fails to specify that the wiring structure includes plural cap films formed at least on upper faces of the wiring films, which are separated by the grooves and have substantially the same shape as uppermost faces of the protrusions" (see page 4, lines 14-17 of the Final Office Action dated January 10, 2007).

In an effort to overcome these acknowledged deficiencies of the Lim et al. reference, the Examiner has asserted on page 4, lines 18-19 of the Final Office Action

dated January 10, 2007, that the Higashi et al. reference "teaches that a cap film may be selectively formed **only on wiring** in order to reduce the capacitance (col 3 ln 8-18) and wiring resistance" (our emphasis added). The Examiner has asserted that it would have been obvious to one of ordinary skill to use the teachings of the Higashi et al. reference on the device of the Lim et al. reference to reduce capacitance and wiring resistance. The Examiner has further asserted that the resulting structure would have a selective cap layer on the wiring that meets the limitation wherein cap films are formed on upper faces of the wiring films and have substantially the shape of uppermost faces of the protrusions. Appellant respectfully disagrees for the following reasons.

As acknowledged by the Examiner, Fig. 14 of the Lim et al. reference as primarily relied upon does not include a cap film. As a point of emphasis, as noted above the Examiner has interpreted the hillock in second dielectric layer 72 that immediately surrounds second copper layer 84/third barrier layer 80 as the protrusion of claim 12.

Regarding the Higashi et al. reference as secondarily relied upon, as should be understood in view of the rejection under 35 U.S.C. 102(b) beginning on page 2 of the Final Office Action dated January 10, 2007, the Examiner has interpreted TiN film 9 in Fig. 1G of the Higashi et al. reference as equivalent to the cap film as featured in claim 12. However, as may be readily understood in view of Fig. 1G of the Higashi et al. reference as relied upon by the Examiner, TiN film 9 is formed specifically on the top edges of TiN metal layer 5 and on copper metal layer 6. TiN film 9 in Fig. 1G of the

Higashi et al. reference as relied upon does not extend to also cover an upper surface of insulation film 1.

As noted above, the Examiner has specifically relied upon the Higashi et al. reference as "teaching a cap film that may be selectively formed only on wiring" (our emphasis added). However, in contrast, the plural cap films of claim 12 are "formed at least on upper faces of the wiring film, and not only on wiring.

Accordingly, even if one of ordinary skill was properly motivated to modify the structure in Fig. 14 of the Lim et al. reference in view of the teaching as related to Fig. 1G of the Higashi et al. reference, the structure in Fig. 14 of the Lim et al. reference would include a TiN film as a barrier (cap) layer as limited to be only on top edges of third barrier layer 80 and on second copper layer 84. Clearly, such a TiN film would not extend onto the hillock of second dielectric layer 72 immediately surrounding second copper layer 84/third barrier 80 in Fig. 14 of the Lim et al. reference.

Thus, since the structure in Fig. 14 of the Lim et al. reference modified in the manner as suggested by the Examiner would include a TiN film only on second copper layer 84 and on third barrier layer 80, and not extending onto the hillock in second dielectric layer 72, it should be evidently clear that the TiN film of the combined teaching could not possibly have "substantially the same shape as uppermost faces" of the hillock. Since the TiN film of the combined teaching would not extend onto the hillock, there clearly can be no sameness between the shape of the TiN film and the shape of the uppermost face of the hillock.

On page 2 of the Advisory Action dated May 2, 2007, the Examiner has asserted:

"Lim (US 6,380,084) discloses wiring that is substantially the same shape, though not the same size (width), as protrusions. The cap film taught by Higashi (US 6,342,444) is formed selectively on the wiring and therefore has substantially the same shape, though not necessarily the same size, as the protrusions".

Appellant respectfully submits that this above noted position as taken by the Examiner in the Advisory Action dated May 2, 2007, is unclear. Since the TiN (cap) film of the prior art as combined is formed selectively only on the wiring as acknowledged by the Examiner, regardless of the size of the TiN (cap) film, the shape of the TiN (cap) film cannot be substantially the same "as the uppermost faces" of the hillock. That is, the TiN (cap) film does not extend onto the upper faces of the hillock of the combined prior art, and thus does not have a shape that extends substantially the same or that is substantially equivalent as the shape of the surrounding hillock. **If anything, the shape of the TiN (cap) film of the combined prior art would presumably be substantially the same as the shape of the uppermost face of the wiring that the TiN (cap) film is disposed selectively on.**

Accordingly, Appellant respectfully submits that the prior art as relied upon by the Examiner does not meet the features of the wiring structure of a semiconductor device of claim 12. The Examiner has not established any teaching or motivation that would

suggest or make obvious a cap film having substantially the same shape as uppermost faces of protrusions, as featured in claim 12. Appellant therefore respectfully submits that the wiring structure of a semiconductor device of claim 12 would not have been obvious in view of the prior art as relied upon by the Examiner taken singularly or together, and that this rejection of claims 12-15 and 33 is improper for at least these reasons.

(2) Claims 16, 28-32 and 34 are patentable over the combination of the Higashi et al. reference and the Lim et al. reference, in further view of the Yu et al. reference

Claims 16, 28-32 and 34 have been rejected under 35 U.S.C. 103(a) as being unpatentable over the Higashi et al. reference and the Lim et al. reference, in further view of the Yu et al. reference. This rejection is respectfully traversed for the following reasons.

Claims 29-32 and 34

The wiring structure of a semiconductor device of claim 28 includes in combination a first insulating film "having plural protrusions in which grooves are formed, and which has an interface in a horizontal direction between adjoining protrusions"; plural wiring films "embedded in the grooves on barrier films"; plural first cap films "formed on upper faces of the protrusions"; and second cap films "formed on the first cap films and the first insulating films, wherein the protrusions are formed through etching the first insulating film, using the first cap films as a mask, and the first

cap films have substantially the same shape as uppermost faces of the protrusions". Appellant respectfully submits that the prior art as relied upon does not make obvious the wiring structure of a semiconductor device of claim 28 for at least the following reasons.

Regarding claim 28, the Examiner has primarily relied upon the Lim et al. reference as disclosed in Fig. 14 as noted previously above with respect to claim 12. The Examiner has however acknowledged that the primarily relied upon Lim et al. reference fails to specify that the wiring structure includes plural first cap films formed on upper faces of the protrusions with substantially the same shape as uppermost faces of the protrusions, and second cap films formed on the first cap films and the first insulating film. (see page 6, lines 10-13 of the Final Office Action dated January 10, 2007).

In an effort to overcome the above noted deficiencies of the primarily relied upon Lim et al. reference, the Examiner has secondarily relied upon the Higashi et al. reference in a somewhat similar manner as noted above with respect to claim 12. The Examiner has noted that the Higashi et al. reference teaches a cap film that may be selectively formed only on wiring, and has asserted that the resultant combined structure "meets the limitation wherein first cap films are formed on upper faces of the wiring films and have substantially the shape as uppermost faces of the protrusions".

Appellant firstly respectfully emphasizes that the Examiner has misconstrued the features of claim 28. In particular, the plural first cap films of claim 28 are featured as

“formed on upper faces of the protrusions”, and are not featured as formed on upper faces of the wiring films as asserted by the Examiner.

As noted above, the Examiner has relied upon the Higashi et al. reference to teach a cap film selectively formed only on wiring. The TiN (cap) film in Fig. 1G of the Higashi et al. reference is formed specifically on top edges of TiN metal layer 5 and on copper metal layer 6, and does not extend to also cover an upper surface of insulation film 1. Accordingly, the structure in Fig. 14 of the Lim et al. reference as modified in view of the teaching of the Higashi et al. reference as relied upon by the Examiner, would not include in combination first cap films formed on upper faces of the hillock in second dielectric layer 72, as would be necessary to meet or make obvious these features of claim 28. Appellant therefore respectfully submits that this rejection of claim 28 is improper for at least these reasons.

Moreover, as emphasized previously, since the Higashi et al. reference as relied upon by the Examiner teaches the TiN (cap) film as selectively formed only on the wiring, the structure in Fig. 14 of the Lim et al. reference modified in view of the above noted teaching of the Higashi et al. reference would not include a first cap film having substantially the same shape as uppermost faces of the hillocks, as would be necessary to meet the further features of claim 28. That is, regardless of the size of the TiN (cap) film of the combined teaching, since the cap film is limited as formed only on the wiring and not on the hillocks, the shape of such TiN (cap) film would presumably have substantially the same shape as the uppermost faces of the wiring. The prior art

as relied upon thus fails to meet or make obvious these further features of claim 28.

Appellant therefore respectfully submits that this rejection of claim 28 is improper for at least these additional reasons.

Thirdly, the Examiner has relied upon the Yu et al. reference as teaching in column 5, lines 33-36, a second insulating cap film that may be formed over a first selectively formed conductive film. Particularly, column 5, lines 33-36 of the Yu et al. reference set forth the following:

"In another embodiment, a conductive passivation layer (not shown) can be formed only overlying the second conductor as a capping layer. Preferably, the conductor passivation layer can be formed by self-aligned process".

It is not entirely clear how the Examiner has applied the teaching of the secondarily relied upon Yu et al. reference to modify the primary teachings. Particularly, the conductive passivating layer as described in column 5, lines 33-36 of the Yu et al. reference as specifically relied upon by the Examiner, is not shown in the figures. The conductive passivating layer is described as formed only overlying the second conductor as a capping layer. This unillustrated conductive passivation layer of the Yu et al. reference is thus formed only on a second conductor, and not on a first cap film and on a first insulating film, as would be necessary to meet the features of claim 28. Even if proper additional motivation existed for modifying the structure in Fig. 14 of the Lim et al. reference previously modified to include a TiN (cap) film only on the wiring (which additional motivation Appellant does not admit exists), the structure would

apparently also include a conductive passivating layer "only overlying" a conductor (wiring). This teaching of the Yu et al. reference would appear to be somewhat similar to the teaching provided with respect to Fig. 1G of the Higashi et al. reference, and would fail to provide the necessary motivation to modify the prior art to meet the features of a second cap film being formed on first cap film and on first insulating film, as in claim 28. Appellant respectfully submits that this rejection of claim 28 is improper for at least these additional reasons.

Accordingly, Appellant respectfully submits that the wiring structure of a semiconductor device of claim 28 would not have been obvious in view of the prior art as relied upon by the Examiner taken singularly or together, and that this rejection of claims 28-32 and 34, is improper for at least these reasons.

Conclusion

Appellant respectfully submits that claims 12-16 and 28-34 would not have been obvious in view of the prior art as relied upon by the Examiner taken singularly or together. Appellant therefore respectfully requests that the final rejections of claims 12-16 and 28-34 be withdrawn, and that these corresponding claims be passed to issue.

In the event that there are any outstanding matters remaining in the present application, please contact Andrew J. Telesz, Jr. (Reg. No. 33,581) at (571) 283-0720 in the Washington, D.C. area, to discuss these matters.

The required fee of \$500.00 under 37 C.F.R. 41.20 for filing this Appeal Brief

should be charged to Deposit Account No. 50-0238.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment for any additional fees that may be required under 37 C.F.R. 41.20 or 37 C.F.R. 1.17 and 1.136(a), or credit any overpayment, to Deposit Account No. 50-0238.

Respectfully submitted,

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Appendix - Claims on Appeal

Claim 12: A wiring structure of a semiconductor device, comprising:

a first insulating film having plural grooves formed therein, which has an interface in a horizontal direction between adjoining grooves;

plural wiring films formed in the grooves of the first insulating film to protrude above the interface;

plural barrier films formed on bottoms of the wiring films, and formed on side faces of the wiring films to a height exceeding the interface; and

plural cap films formed at least on upper faces of the wiring films, and which are each separated by the grooves,

wherein the first insulating film has plural protrusions protruding from the interface, and the grooves are formed in the protrusions,

wherein the upper faces of the wiring films and the barrier films are substantially coincident with upper ends of the grooves, and

wherein the protrusions are formed through etching the first insulating film, using the cap films as a mask, and the cap films have substantially the same shape as uppermost faces of the protrusions.

Claim 13: A wiring structure of a semiconductor device as claimed in Claim 12, wherein the cap films are a metal film made of Ta_xN_y , Ta, or $Ta_xSi_yN_z$.

Claim 14: A wiring structure of a semiconductor device as claimed in Claim 12, wherein the cap films are a metal film made of Ti_xN_y or $Ti_xSi_yN_z$.

Claim 15: A wiring structure of a semiconductor device as claimed in Claim 12,
wherein the cap films are a metal film made of W_xN_y or $W_xSi_yN_z$.

Claim 16: A wiring structure of a semiconductor device as claimed in Claim 12,
wherein the cap films are an insulating film containing Si_xN_y , $Si_xO_yN_z$, Si_xC_y , or Si_xC_y
as a principal composition.

Claim 28: A wiring structure of a semiconductor device, comprising:
a first insulating film having plural protrusions in which grooves are formed,
and which has an interface in a horizontal direction between adjoining protrusions;
plural wiring films embedded in the grooves on barrier films;
plural first cap films formed on upper faces of the protrusions; and
second cap films formed on the first cap films and the first insulating film,
wherein the protrusions are formed through etching the first insulating film,
using the first cap films as a mask, and the first cap films have substantially the
same shape as uppermost faces of the protrusions.

Claim 29: A wiring structure of a semiconductor device as claimed in Claim 28,
wherein the first cap films are a metal film made of Ta_xN_y , Ta, or $Ta_xSi_yN_z$.

Claim 30: A wiring structure of a semiconductor device as claimed in Claim 28,
wherein the first cap films are a metal film made of Ti_xN_y or $Ti_xSi_yN_z$.

Claim 31: A wiring structure of a semiconductor device as claimed in Claim 28,
wherein the first cap films are a metal film made of W_xN_y or $W_xSi_yN_z$.

Claim 32: A wiring structure of a semiconductor device as claimed in Claim 28, wherein the second cap films are an insulating film containing Si_xN_y , $\text{Si}_x\text{O}_y\text{N}_z$, Si_xC_y , or Si_xC_y as a principal composition.

Claim 33 (Previously Presented): A wiring structure of a semiconductor device as claimed in Claim 12, wherein the cap films are a metal film containing tungsten as a principal composition.

Claim 34: A wiring structure of a semiconductor device as claimed in Claim 28, wherein the first cap films are a metal film containing tungsten as a principal composition.

Evidence Appendix

No evidence has been submitted under 37 C.F.R. 1.130, 1.131, or 1.132, or entered by the Examiner in connection with this pending Appeal. Thus, there are **no** copies of evidence included in this Appendix.

Related Proceedings Appendix

There are no Appeals or Interferences that may be related to, directly affect, or be directly affected by or have a bearing on the Decision by the Board in this pending Appeal. Thus, there are **no** copies of decisions included in this Appendix.